CFD Modeling of SNCR Performance in Conectiv's Indian River Units 3 and 4

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INTRODUCTION

Hamon-Research Cottrell has been contracted by Conectiv to design, manufacture, assist with installation, and test SNCR injection systems in their Indian River Units 3 and 4 located near Millsboro, Delaware. This presentation discusses the results of the SNCR injection system design phase of this program, primarily the results of the CFD modeling that was conducted to estimate SNCR performance and to aid in the design of these systems.

Indian River Unit 3 utilizes a 178 MW B&W front wall fired boiler that was retrofit in 1995 with a Riley Low-NOx firing system which reduced NOx emissions from 1.0 to 0.3 lbs/MMBtu. Unit 4 utilizes a 440 MW D.B. Riley turbo, opposed wall fired boiler equipped with 24 Riley Low-NOx burners with separated overfire air. The baseline NOx emissions for this unit are 0.4 lbs/MMBtu.

FIELD MEASUREMENTS

For both units, field measurements including furnace exit gas temperatures and emissions characteristics were taken over a range of loads from 25 to 100% of full load. Suction pyrometry utilizing high velocity thermocouple (HVT) probes was used to collect the furnace gas temperature data at furnace depths of 4 and 8 ft. In Indian River 3, measurements were made through three front wall ports at two elevations near the furnace exit and at two side wall ports within the convective section. The measurements at full load indicated favorable furnace exit gas temperatures averaging 2090^{o}F at the furnace exit.

In Indian River 4, measurements were made through 3 front wall ports at one elevation and 6 side wall ports at two elevations. The temperature measurements showed a significant variation in temperature across the furnace depth with cooler temperatures adjacent to the front wall (measured through the front wall ports) and much higher temperatures toward the rear wall (measured through the side wall ports). At full load, the measurements indicated that favorable

SNCR temperatures exist at the entrance to the furnace back pass (near the outlet of the high temperature superheat).

CFD MODELING

The computational tools used during this program simulate reacting and nonreacting flow of gases and particles, applicable to gaseous diffusion flames, pulverized-coal flames, liquid sprays, reacting two-phase flows and other oxidation/reduction systems. *BANFF* is Reaction Engineering International's (REI) three-dimensional, gas-phase turbulent reacting flow code, and *GLACIER* adds physical models to treat two-phase flows. These software tools have been applied to a wide variety of industrial systems encompassing utility boilers, pyrolysis furnaces, gas turbine combustors, rotary kilns, waste incinerators, smelting cyclones and others.

BANFF and *GLACIER* fully couple together the chemistry of reacting gases, solids and liquids with turbulent mixing and radiative heat transfer. Coupling turbulence and heat transfer with finite-rate reaction chemistry requires the number of chemical kinetic steps to be relatively small. *BANFF* and *GLACIER* use assumptions of partial equilibrium and steady state species to compute local finite-rate chemistry using a set of reduced kinetic steps for slow reactions and minimize Gibbs free energy for all other species. A reduced set of seven global SNCR reactions is fully coupled into *BANFF* and *GLACIER*. This reduced chemistry is based on the kinetic rates of Miller and Bowman with recent literature modifications.

RESULTS AND DISCUSSION

The CFD modeling, combined with the results of the temperature measurements, along with the hardware constraints existing within both units lead to the final injection system designs. The final injection system design in Indian River Unit 3 consists of four zones utilizing low-energy aqueous urea injection: one zone of rear and side wall injectors, two zones of front wall injectors, and one zone of multinozzle lances in the convective cavity separating the inlet and outlet secondary superheat tubes. The CFD model predictions indicate that at full load, NOx reductions of 30-35%, with less than an average of 5 ppm ammonia slip, should be achievable in Unit 3, utilizing a combination of upper front wall and MNL injection. At reduced loads, NOx reductions of 35-40% with less than 5 ppm ammonia slip were predicted.

The injection system design in Indian River Unit 4 consists of five injection zones: one zone of lower rear wall injectors, two zones of front and side wall injectors, and two zones of 27 ft. long MNLs located near the outlet of the high temperature superheat tubes. Since this boiler has no nose, a large region of recirculating flue gas adjacent to the front wall and roof is predicted to lead to a large temperature variation across the width and depth of the boiler. The CFD predictions indicate that at full load, NOx reductions of 30-35% should be achievable, utilizing only the MNLs, while keeping ammonia slip below an average of 15 ppm.. At reduced loads, NOx reductions of 35-40% with less than 15 ppm ammonia slip are predicted.